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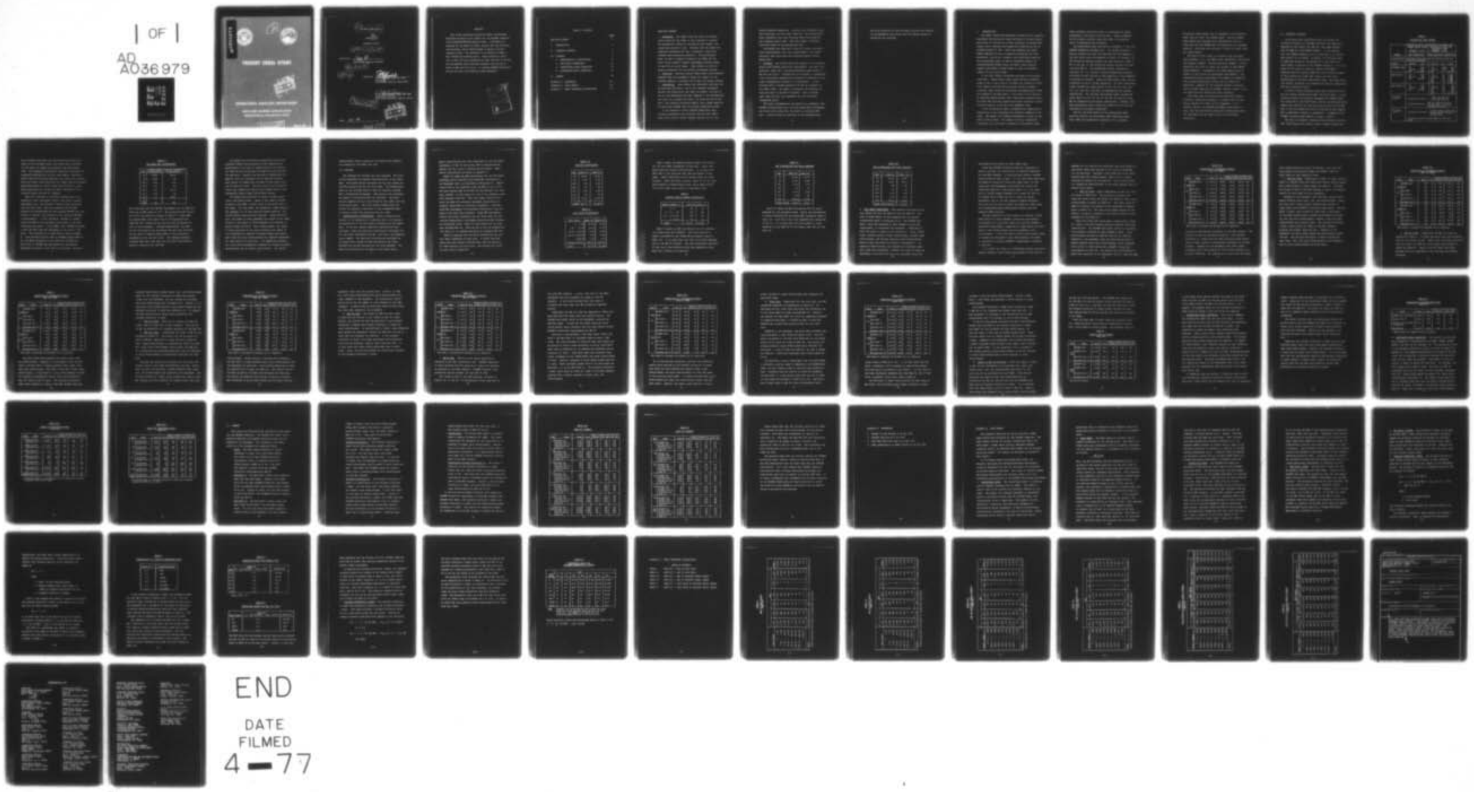

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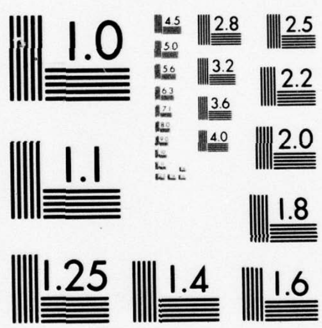
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TRIDENT COSAL STUDY

OPERATIONS ANALYSIS DEPARTMENT

NAVY FLEET MATERIAL SUPPORT OFFICE
Mechanicsburg, Pennsylvania 17055

Report 129

6 TRIDENT COSAL STUDY

14 REPORT 129

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ABSTRACT

This study evaluates alternative COSAL (Coordinated Shipboard Allowance List) models for the TRIDENT submarine using POLARIS/POSEIDON submarine data. Performance is measured by the range of items, overall cost and resulting effectiveness, where effectiveness is based on actual submarine usage. The objective is to develop a COSAL to meet TRIDENT performance goals. These protection goals vary by MEC (Military Essentiality Code) from 90% to 99.99%. The recommended model provides variable item protection based on MEC and unit price. It attains TRIDENT objectives and was the most cost-effective model examined.

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EXECUTIVE SUMMARY

1. Background. The COSAL lists the range of on-board repair parts and the depth of each required to sustain the operational mission of the ship by self-support for a specified period of time. The Navy uses two models for computing allowances for hull, mechanical, electrical, ordnance and electronics materials. The Conventional model is used to compute allowances for SSBNs and the FLSIP (Fleet Logistic Support Improvement Program) model is used for all other ships. Other models are used to compute allowances for the nuclear and weapons systems.

2. Objective. Evaluate various COSAL models using POLARIS/POSEIDON data and recommend a model for support of the TRIDENT submarine, excluding the nuclear and weapon systems.

3. Methodology. Seven models were evaluated including the Conventional and FLSIP. Due to the inherent difference between the Conventional and other six models, the best of the six was determined and then compared to the Conventional. The other six included the FLSIP, two modifications of the FLSIP, two variable protection models, and a model based on the specified TRIDENT Goal by Military Essentiality Code.

In the absence of actual TRIDENT operational data, allowance candidates were selected from the SPCC (Navy Ships Parts Control Center) Weapons System file for two

POLARIS/POSEIDON submarines. Actually four candidate files were developed, two from each submarine. The Conventional model candidate files (one from each ship) were based on the allowance factor code. The other models' candidate files were based on the maintenance code.

Performance was measured by range of items, investment, range effectiveness, and units effectiveness. The COSAL developed under each model was exercised against actual demand data.

4. Findings. The results show that several of the proposed models meet TRIDENT protection requirements. The most cost-effective model was a variable protection model based on MEC and unit price. Presentation of the model to representatives from higher headquarters resulted in acceptance of the study recommendation subject to a stipulation. It was directed that a minimum protection of 90% be provided for all COSAL items. The impact is primarily an extension of range and cost in the MEC 95 category. Costs increase less than 10% over the investment for the originally recommended model.

The study recommendation was based on an assumption that TRIDENT configuration data, on-board maintenance philosophy, and actual parts usage will be similar to existing SSBN data. Caution should be exercised in the implementation

and early operation of the new model to prove the validity of the assumption and ensure that the desired levels of protection are attained.

I. INTRODUCTION

The COSAL (Coordinated Shipboard Allowance List) quantity represents the authorized range and depth of on-board repair parts that is required for a ship to perform its operational mission and to achieve self-supporting capabilities for an extended period of time. There are presently two COSAL models approved for use in computing allowances for hull, mechanical, electrical, ordnance, and electronics material. The Conventional model is used to determine support for POLARIS/POSEIDON SSBNs, while the FLSIP (Fleet Logistic Support Improvement Program) model is used to determine support for all other ships.

In the FLSIP model, allowances are based on historical usage data. Demand based items (those having an expected usage of one or more units in 90 days) are stocked in sufficient depth to provide 90% protection against stockout. Insurance items (those not qualifying as demand based items) are stocked in minimum depth, if the item is vital and has an expected demand greater than a specified exclusion value. The FLSIP MEC (Military Essentiality Code) requires a vital/nonvital decision at the part and component level.

In the Conventional model, allowances are computed by a combination of two techniques for different segments of the COSAL. The support for ordnance equipments is based on the FLSIP criteria above. The support for hull, mechanical, electrical, and electronic equipments is determined using

fixed allowance quantities which are determined by manual procedures at the time of provisioning. These procedures do not directly consider usage data, MEC, or protection level in determining the allowance.

The performance goals specified in reference (1) for the TRIDENT submarines allowance are: (1) 99.99% protection against stockout for each item with MEC 116--the absence of the part could cause the submarine to abort its mission; (2) 99% protection against stockout for each item with a MEC of 98 to 110; and (3) 90% protection against stockout for each item with MEC 95. The TRIDENT MEC system, described in reference (2), is a relative ranking system which measures the effect of part failure on the capability of the submarine to perform its mission. Under this MEC system, each item is classified in one of 14 MEC categories. For ship installable items, the MEC can range from 95 to 116 (95, 98, 101, 104, 107, 110, and 116), with MEC 116 representing the highest essentiality. For non-ship installable items, the MEC can range from 37 to 58 (37, 40, 43, 46, 49, 52, and 58), with MEC 58 representing the highest essentiality. However, only ship installable items (items with a MEC of 95 to 116) are considered as allowance candidates.

Neither the FLSIP model nor the Conventional model directly consider the performance goals specified above. Thus, FMSO was requested by reference (3) to evaluate

alternative COSAL models and to recommend a cost-effective model that will meet the TRIDENT goals. Various TRIDENT COSAL models were designed with consideration given to usage data and the TRIDENT MEC in determining the allowance quantity. Each model was evaluated in terms of range, cost, and effectiveness.

The scope of this study is limited to only the basic COSAL segments, i.e., the HME&O (Hull, Mechanical, Electrical, and Ordnance) segment and the electronic segment. No consideration was given to either the nuclear or SSPO Weapon System segments. Furthermore, the study applies only to support of the corrective maintenance requirements. Any planned maintenance requirements for support of submarine level planned maintenance actions will be identified separately, compared to the allowance quantity resulting from the model selected for TRIDENT, and the greater of the two quantities will become the final allowance.

This study does not evaluate the trade-offs between stocking a repairable component or stocking the bits and pieces required for repair of the component. It is assumed, based on the TRIDENT equipments identified to date, that the maintenance coding will seldom permit both the repairable and the repair parts to be allowance candidates.

II. TECHNICAL APPROACH

Since there were insufficient data to evaluate the alternative models on a TRIDENT data base, two SSBNs were selected as test ships--the SSBN 627 (USS JAMES MADISON) and the SSBN 633 (USS CASMIR PULASKI). It was assumed that the TRIDENT submarine will be operating in an environment similar to the SSBNs. Therefore, the findings based on SSBN data should be representative of the trends one would expect to observe on the TRIDENT submarine. It is not known at this point in time how similar the TRIDENT submarine and the existing SSBNs will be in terms of number of ship installable items, MEC coding, and unit price distribution of the ship installable items. The study findings should, therefore, be considered as relative comparisons and not as absolute values.

A total of seven different models were evaluated including the current Conventional model, the FLSIP model, a fixed protection model that directly addresses the TRIDENT goals, two variations of the FLSIP model, and two variable protection models that consider the item unit price as well as the MEC. Each of the test models was built to provide 90 days support and is described in detail in Appendix B. A summary of all TRIDENT allowance COSAL models is shown in Table I.

Two sets of allowance candidates were extracted from the SPCC (Navy Ships Parts Control Center) Weapons System File.

TABLE I

ALTERNATIVE COSAL MODELS

	PROTECTION LEVEL FOR DEMAND BASED ITEMS (DEMAND $\geq$ 4/YR)		EXCLUSION CRITERIA AND PROTECTION LEVEL FOR INSURANCE ITEMS (DEMAND $<$ 4/YR)		
MODEL	MEC	PROTECTION	MEC	EXCLUSION	PROTECTION
Conventional	Exclusion Criteria and Protection Level Not Directly Addressed				
FLSIP	95-116	90%	95-116	.25	1 MRU
TRIDENT Goal	95 98-110 116	90% 99% 99.99%	95 98-110 116	.4216 .0404 0	90% 99% 99.99%
Mod FLSIP I	95 98-110 116	90% 99% 99.99%	95 98-104 107 110 116	.25 .15 .10 .05 0	1 MRU 1 MRU 1 MRU 1 MRU 1 MRU
Mod FLSIP II	95 98-110 116	90% 99% 99.99%	95 98-104 107 110 116	.25 .15 .10 .05 0	90% 99% 99% 99% 99.99%
Variable Prot I	Exclusion Criteria = $\left\{\begin{matrix}.3856 \text{ for MEC } 95 \\ 0 \text{ for MEC } 98\text{-}116\end{matrix}\right\}$ Protection Level = 90% for MEC 95; Varies based on MEC and price for MEC 98 to 116				
Variable Prot II	Exclusion Criteria = varies based on MEC and price for MEC 95-110; 0 for MEC 116 Protection Level varies based on MEC and price				

The allowance candidates for the Conventional model were based on the allowance factor code while those selected for the other six models were based on the maintenance code. Only submarine installable items were considered as allowance candidates for the six test models. Operating Space Items and Allowance Equipage List items were excluded from this study since quantities for these items are manually established based on factors other than historical usage. These quantities will remain the same, regardless of the allowance model selected for TRIDENT.

Most data required for allowance computations (item population, best replacement factor, unit price, minimum replacement unit, and technical override) were extracted from the SPCC files. The only exception was the MEC. Although the TRIDENT MECs and the existing FBM MEC are very similar in concept, the validity of the existing FBM MECs is questionable. It was, therefore, decided to randomly assign the MECs at the equipment level based on the best information available. In the HME&O area, TRIDENT personnel in SPCC had MEC coded 990 equipments at the time of this study. The distribution of these MECs is shown in Table II. This distribution was used to randomly assign MECs to all the HME&O equipments on the SSBN 627 and SSBN 633. There were no TRIDENT MEC assignments for electronics equipments available at the time of this study. The best

TABLE II

EQUIPMENT MEC DISTRIBUTIONS

MEC	TRIDENT HME&O DISTRIBUTION	SSBN 627 ELECTRONIC DISTRIBUTION
95	79.8%	44.1%
98	14.6%	0%
101	2.0%	7.8%
104	.2%	0%
107	1.3%	12.3%
110	1.5%	0%
116	.6%	35.8%
NR APLs	990	399

data available were the FBM MEC assignments for the SSBN 627, which was re-MEC coded in 1973. The electronics MEC distribution for the SSBN 627 is shown in Table II. These MECs are questionable since about 36% of the equipments were coded MEC 116, indicating the mission could be aborted for lack of this equipment. Although questionable, the SSBN 627 MEC distribution was considered the best data available and was used to randomly assign MECs to the electronics equipments on the two test ships. The randomly assigned equipment MECs were then used with the item vital/nonvital coding to determine the item MEC.

All models were evaluated by comparison with actual shipboard demand data provided by Vitro Laboratories. Approximately five years of demand history--20 quarters for SSBN 627 and 18 quarters for SSBN 633--were provided for each ship. However, two quarters of demand data for SSBN 627 were not considered due to abnormal demands. Each quarter of demand data included 60 days patrol data and 30 days refit data. The Vitro data file included all repair part demands as reported into ACCESS (Afloat Cost Consumption Effectiveness Surveillance System).

All models were evaluated in terms of range, dollar value, and effectiveness. Range is the number of NIINs allowed on the COSAL. Dollar value is the total cost of the COSAL. For each model, the candidate's COSAL quantity was compared to a 90 days observed demand quantity. Two effectiveness statistics were computed. Range effectiveness, the number of NIINs demanded and allowed on the COSAL divided by the number of NIINs demanded, was computed to measure range selection. Units effectiveness, the number of units satisfied in the range divided by the number of units demanded was computed to measure depth performance. Both range and units effectiveness were computed separately for each quarter for each ship. For comparison purposes, two range effectivenesses were computed--an average quarterly effectiveness and an overall effectiveness. The overall

effectiveness covers a period of 18 quarters and reflects the coverage of the COSAL over time.

III. FINDINGS

The findings are divided into four sections. The first section describes the general characteristics of the input data. The second section evaluates the six test models for each MEC category and for the total ship. The Conventional model is not included since it does not directly consider MEC in determining allowances. This section also evaluates the impact of eliminating MEC 116 overrides. The third section compares the most cost-effective test model with the Conventional model. The final section demonstrates the results of applying a constraint to the recommended model to assure at least 90% protection for all items.

A. CHARACTERISTIC DISTRIBUTIONS. Before evaluating the results, it is appropriate to identify some of the general characteristics of the test model candidates and the demand data. To do this, several empirical distributions were developed. Among the empirical distributions developed for the test model candidates were MEC, unit price, and expected annual demand. The empirical distributions developed for the demand data include the MEC distribution for NIINs demanded and the MEC distribution for units demanded. All empirical distributions are shown in the tables below.

Matrix distributions were also developed for the test model candidates for MEC vs unit price, MEC vs expected annual demand, and unit price vs expected annual demand. These matrix distributions are shown in Appendix C.

Table III shows the MEC distribution for the test model candidates which resulted from random MEC assignments at the equipment level, as described in Paragraph II. Approximately 80% of the candidate items had MECs of 95 or 116. The split between MEC 95 and MEC 116 was different for each ship; however, in both cases over 20% of the candidate items were assigned a MEC 116. This high number resulted from using the SSBN 627 electronic equipment distribution to randomly assign MECs to electronic equipments. Although these MEC assignments are considered unrealistic, they are based on the best data available. These MEC assignments distort the actual statistics for the total ship, but the relative comparisons of the models within each MEC category are considered valid. Table III also shows that no items were assigned MEC 104. This was due to the low probability (See Table II) of randomly assigning an equipment MEC 104.

Table IV displays the unit price distribution for the test model candidates of each ship. It shows that both ships have very similar distributions, with the majority of items having a low unit price. The average unit price for each item is about $70.

TABLE III

ITEM MEC DISTRIBUTION

MEC	SSBN 627	SSBN 633
95	46.3%	56.6%
98	9.0%	9.2%
101	.9%	2.9%
104	0%	0%
107	7.9%	9.6%
110	.2%	.2%
116	35.7%	21.5%
TOTAL	30,717	30,348

TABLE IV

UNIT PRICE DISTRIBUTION

UNIT PRICE	SSBN 627	SSBN 633
$\leq$ 1.00	35.2%	34.4%
1.01 - 10.00	32.5%	32.4%
10.01 - 100.00	23.4%	23.5%
100.01 -1000.00	7.8%	8.6%
>1000.00	1.1%	1.1%
Average Price	$66.47	$72.55
TOTAL	30,717	30,348

Table V shows the expected annual demand distribution for the test model candidates of each ship. Again, both ships have very similar distributions. It is noted that about 80% of the items had less than one demand in four years. These items would not be stocked under the FLISP criteria. Under the FLSIP criteria, about 3% of the items would qualify as demand based items, while approximately 17% of the items would qualify as insurance items.

TABLE V

EXPECTED ANNUAL DEMAND DISTRIBUTION

ANNUAL DEMAND (D)	SSBN 627	SSBN 633
$D = 0$	6%	6%
$0 < D \leq .25$	73%	74%
$.25 < D \leq 4.00$	18%	17%
$D > 4.00$	3%	3%
TOTAL	30,717	30,348

Table VI shows the MEC distribution for all candidate file NIINs which were demanded. This distribution is highly influenced by the random MEC assignments shown in Table III. It is noted that over 50% of the NIINs demanded were in the MEC 95 category. The most significant statistic is that only 3,000 different NIINs were demanded on each ship over a period of 18 quarters.

TABLE VI

MEC DISTRIBUTION FOR NIINs DEMANDED

MEC	SSBN 627	SSBN 633
95	55.9%	62.7%
98	15.2%	14.8%
101	1.1%	1.7%
104	0%	0%
107	4.7%	8.8%
110	.5%	.6%
116	22.6%	11.4%
TOTAL NIINs	3,001	2,817

Table VII shows the MEC distribution for all units demanded for the candidate items. Again, the distribution is highly influenced by the random MEC assignment shown in Table III. Over 50% of the units demanded were classified in MEC 95. It is noted that the total number of units demanded for the SSBN 627 is 14% higher than that for the SSBN 633.

TABLE VII

MEC DISTRIBUTION FOR UNITS DEMANDED

MEC	SSBN 627	SSBN 633
95	51.9%	55.4%
98	18.3%	20.1%
101	.9%	1.4%
104	0%	0%
107	3.3%	7.9%
110	2.1%	1.1%
116	23.5%	14.1%
TOTAL UNITS	48,658	42,703

B. TEST MODEL COMPARISONS. This section evaluates the six test models for both the SSBN 627 and the SSBN 633. The best of these models is then compared with the current Conventional model in Paragraph III.C. The TRIDENT Goal model, which was developed to meet TRIDENT's protection requirements, is considered the benchmark. Comparison of each test model is based on five statistics: range, dollar value, average quarterly range effectiveness, overall range effectiveness, and average quarterly units effectiveness. Each of these statistics is defined in Paragraph II. In computing effectiveness, only demands for allowance candidate items were considered. Demands for items not shown as candidates in the SPCC file were not considered since the

test model had no chance to stock these items.

Since the TRIDENT protection goals are expressed in terms of the MEC, the results will be analyzed separately for each MEC category. In analyzing the results, several points should be kept in mind: (1) all test model quantities are based on historical fleet-wide usage rates; (2) SIM (Selective Item Management) procedures will adjust the authorized depth for "fast moving items" i.e., for items with an initial demand frequency of at least two hits in six months and at least one hit in every six months thereafter; and (3) the LSA (Logistic Support Analysis) data file will be used to adjust the depth for those items with Planned Maintenance Requirements higher than the computed COSAL quantity.

The main objective of this study is to develop a COSAL model which will meet TRIDENT's protection requirements. To determine if a particular model will satisfy TRIDENT's protection requirements, comparison is made between the test model's units effectiveness and the benchmark's units effectiveness. If the test model's units effectiveness meets or exceeds the benchmark's units effectiveness, the model is considered to satisfy TRIDENT's requirements; otherwise, it does not.

It is noted that there is a difference between protection against stockout, which states what percent of the time all

demands for the item will be satisfied, and units effectiveness which states what percent of all the units demanded will be satisfied. Although a high protection level should produce high units effectiveness, there is not a direct correlation between the two measures. Units effectiveness (or requisition effectiveness) is the value commonly used to measure ship support.

1. MEC 116 Items. Model comparisons for MEC 116 items are shown in Table VIII. The statistics indicate that range and dollar values are higher for SSBN 627, while units effectiveness is higher for SSBN 633. The higher range for SSBN 627 reflects the results of the random MEC assignment shown in Table III. The lower units effectiveness for the SSBN 627 is mainly attributed to the larger volume of units demanded for the SSBN 627.

Table VIII shows that every model, except FLSIP, stocks all items in this MEC category and thus produces 100% range effectiveness. The TRIDENT Goal model, which is considered the benchmark, produced the most expensive COSAL. Units effectiveness was 68% for SSBN 627 and 81% for SSBN 633. Compared to the benchmark, both the FLSIP and Mod FLSIP I models produced lower units effectiveness, which indicates that neither of these models meet TRIDENT's protection requirements for MEC 116. The results for the Mod FLSIP II model were identical to the benchmark, since it used the same

TABLE VIII

COMPARISON OF ALTERNATIVE MODELS
MEC 116 ITEMS

SHIP	MODEL	RANGE	$ VALUE	RANGE EFF (OVERALL)	RANGE EFF (AVG QTR)	UNITS EFF (AVG QTR)
SSBN 627	TRIDENT Goal*	10,974	645K	100%	100%	68%
	FLSIP	1,717	75K	63%	81%	58%
	Mod FLSIP I	10,974	556K	100%	100%	63%
	Mod FLSIP II	10,974	645K	100%	100%	68%
	Variable Prot I	10,974	612K	100%	100%	76%
	Variable Prot II	10,974	612K	100%	100%	76%
SSBN 633	TRIDENT Goal*	6,529	524K	100%	100%	81%
	FLSIP	1,362	146K	78%	90%	73%
	Mod FLSIP I	6,529	402K	100%	100%	76%
	Mod FLSIP II	6,529	524K	100%	100%	81%
	Variable Prot I	6,529	461K	100%	100%	88%
	Variable Prot II	6,529	461K	100%	100%	88%

*This model is considered the benchmark for all comparisons

criteria for determining allowances in this MEC category. The results for both the Variable Protection I and Variable Protection II models were the same since both these models used the same criteria in determining allowances in this MEC category. Compared to the benchmark, both these models increased units effectiveness by 7%-8%, while reducing cost by about $30K-$60K. The combination of lower cost and higher

units effectiveness was mainly attributed to the fact that these models provide greater depth for cheaper items and lower depth for more expensive items.

2. MEC 110 Items. Comparisons for MEC 110 items, shown in Table IX, indicate that both ships have similar results except units effectiveness is again higher for SSBN 633. Although the volume of data in this MEC category is small, the general results for each model are very consistent.

Compared to the benchmark, both the FLSIP and Mod FLSIP I models produced lower range, cost, and effectiveness. Again, the lower units effectiveness indicates that neither of these models meet TRIDENT's protection requirements. The Mod FLSIP II model, which stocks the same items as Mod FLSIP I but provides greater depth, matched the benchmark's figures for cost and units effectiveness; however, range and range effectiveness were slightly lower. The Variable Protection I model, which stocks all items in this MEC category, produced the highest range and cost. Compared to the benchmark, its units effectiveness was significantly higher (8%-10%). The Variable Protection II model produced the same range, cost, and range effectiveness as the benchmark, and its units effectiveness was 8%-9% higher.

TABLE IX

COMPARISON OF ALTERNATIVE MODELS
MEC 110 ITEMS

SHIP	MODEL	RANGE	$ VALUE	RANGE EFF (OVERALL)	RANGE EFF (AVG QTR)	UNITS EFF (AVG QTR)
SSBN 627	TRIDENT Goal*	50	3K	100%	100%	85%
	FLSIP	26	1K	94%	97%	84%
	Mod FLSIP I	46	2K	100%	100%	84%
	Mod FLSIP II	46	3K	100%	100%	85%
	Variable Prot I	65	4K	100%	100%	95%
	Variable Prot II	50	3K	100%	100%	94%
SSBN 633	TRIDENT Goal*	49	3K	100%	100%	90%
	FLSIP	30	1K	94%	99%	87%
	Mod FLSIP I	46	2K	94%	99%	87%
	Mod FLSIP II	46	3K	94%	99%	90%
	Variable Prot I	66	5K	100%	100%	98%
	Variable Prot II	49	3K	100%	100%	98%

*This model is considered the benchmark for all comparisons

3. MEC 107 Items. Comparisons for MEC 107 items are displayed in Table X. It shows that both ships have different results, but similar trends. Range, cost, and units effectiveness are higher for SSBN 633, while range effectiveness is higher for SSBN 627. Table VI and VII shows that NIINs demanded and units demanded for the two ships are markedly different.

TABLE X

COMPARISON OF ALTERNATIVE MODELS
MEC 107 ITEMS

SHIP	MODEL	RANGE	$ VALUE	RANGE EFF (OVERALL)	RANGE EFF (AVG QTR)	UNITS EFF (AVG QTR)
SSBN 627	TRIDENT Goal*	724	51K	83%	94%	70%
	FLSIP	287	27K	68%	86%	66%
	Mod FLSIP I	467	36K	77%	91%	67%
	Mod FLSIP II	467	41K	77%	91%	70%
	Variable Prot I	2,424	96K	100%	100%	81%
	Variable Prot II	753	39K	83%	92%	76%
SSBN 633	TRIDENT Goal*	1,185	80K	82%	93%	81%
	FLSIP	474	38K	56%	81%	76%
	Mod FLSIP I	765	53K	71%	88%	78%
	Mod FLSIP II	765	65K	71%	88%	80%
	Variable Prot I	2,923	170K	100%	100%	91%
	Variable Prot II	1,223	60K	79%	91%	87%

*This model is considered the benchmark for all comparisons

The FLSIP model again produced the lowest range, cost, and effectiveness. Compared to the benchmark, both the Mod FLSIP I and Mod FLSIP II models produced lower range, cost, and range effectiveness. Mod FLSIP I also had 3% lower units effectiveness. In Mod FLSIP II, units effectiveness for SSBN 627 matched the benchmark's figure, while units effectiveness for SSBN 633 was 1% lower. The Variable Protection I model again stocked all items in this MEC category and thus

produced significantly higher range, cost, and effectiveness. Range for the Variable Protection II model was slightly higher than the benchmark; cost was reduced by $12K-$20K, and units effectiveness was increased by 6%. However, it is noted that the average quarterly range effectiveness for the Variable Protection II model was reduced by 2%. In general, the most cost-effective results were provided by the Variable Protection II model.

4. MEC 104 Items. There was no analysis for MEC 104 items, since no items fell in this category. This was due to the low probability of randomly assigning an item MEC 104.

5. MEC 101 Items. Comparisons for items in MEC 101 are presented in Table XI. The results for the two ships are again different, especially in range and units effectiveness. Range effectiveness is significantly higher for SSBN 627, while units effectiveness varies widely for SSBN 633. It is noted that the percentage deviation from the benchmark in units effectiveness is significantly different for each ship.

Although the results were different for each ship, the general trend of each model was basically the same. Again, both the FLSIP and Mod FLSIP I models produced lower range, cost, and effectiveness when compared to the benchmark. The Variable Protection I model, again stocked all items in this MEC category and thus produced the highest range, cost, and

TABLE XI

COMPARISON OF ALTERNATIVE MODELS
MEC 101 ITEMS

SHIP	MODEL	RANGE	$ VALUE	RANGE EFF (OVERALL)	RANGE EFF (AVG QTR)	UNITS EFF (AVG QTR)
SSBN 627	TRIDENT Goal*	206	21K	97%	99%	61%
	FLSIP	109	11K	88%	94%	53%
	Mod FLSIP I	129	12K	94%	98%	54%
	Mod FLSIP II	129	19K	94%	98%	60%
	Variable Prot I	289	32K	100%	100%	71%
	Variable Prot II	172	11K	97%	99%	67%
SSBN 633	TRIDENT Goal*	358	20K	79%	88%	64%
	FLSIP	147	8K	53%	67%	48%
	Mod FLSIP I	181	9K	57%	70%	49%
	Mod FLSIP II	181	14K	57%	70%	57%
	Variable Prot I	864	40K	100%	100%	75%
	Variable Prot II	310	11K	70%	76%	63%

*This model is considered the benchmark for all comparisons

effectiveness. Unlike results in previous MEC categories, the Mod FLSIP II model produced lower units effectiveness than the benchmark for each ship. Units effectiveness was 1% lower for SSBN 627 and 7% lower for SSBN 633. The results for the Variable Protection II model were different for each ship. The results for SSBN 627 were similar to those in previous MEC categories as units effectiveness was 6% higher than the

benchmark, while cost was reduced $10K. However, in SSBN 633, both range effectiveness and units effectiveness were lower compared to the benchmark. The inconsistent results may be due to the low number of units demanded in this MEC category. It should also be noted that range for both ships was lower when compared to the benchmark.

6. <u>MEC 98 Items</u>. The trends for MEC 98 items, shown in Table XII are similar to the trends for MEC 101 items. However, the results for both the Mod FLSIP II and Variable Protection II models were slightly different in range and units effectiveness. In the Mod FLSIP II model, units effectiveness matches the benchmark's figure for SSBN 633, but was 1% lower than the benchmark for SSBN 627. In the Variable Protection II model, both ships had higher units effectiveness than the benchmark, despite lower range and cost. It is also noted that range effectiveness was lower on both ships. Again, the most cost-effective results were provided by the Variable Protection II model.

TABLE XII

COMPARISON OF ALTERNATIVE MODELS
MEC 98 ITEMS

SHIP	MODEL	RANGE	$ VALUE	RANGE EFF (OVERALL)	RANGE EFF (AVG QTR)	UNITS EFF (AVG QTR)
	TRIDENT Goal*	1,953	192K	97%	99%	64%
SSBN	FLSIP	1,118	102K	77%	88%	57%
	Mod FLSIP I	1,350	121K	84%	92%	58%
627	Mod FLSIP II	1,350	146K	84%	92%	63%
	Variable Prot I	2,757	294K	100%	100%	72%
	Variable Prot II	1,530	101K	87%	95%	69%
	TRIDENT Goal*	1,967	181K	95%	98%	71%
SSBN	FLSIP	1,115	95K	78%	91%	67%
	Mod FLSIP I	1,338	107K	85%	93%	67%
633	Mod FLSIP II	1,338	128K	85%	93%	71%
	Variable Prot I	2,788	289K	100%	100%	80%
	Variable Prot II	1,535	96K	87%	95%	77%

*This model is considered the benchmark for all comparisons

7. MEC 95 Items. MEC 95 is the lowest essentiality assigned to any ship installable item. TRIDENT experience to date indicates that the majority of items will generally be assigned in this MEC category. TRIDENT requires a 90% protection against stockout for each MEC 95 item.

The volume of data in this MEC category, as shown in Tables III, VI and VII, is considerably larger than that of

any other MEC category. In fact, over half of the model candidates and units demanded are coded in this MEC category. It will later be seen that this tends to influence the total ship (all MEC categories combined) results.

Comparisons for MEC 95 items are displayed in Table XIII. They show that both ships have very similar results. The TRIDENT Goal model, which is the benchmark, produced the smallest range. It also had the lowest range and units effectiveness, which indicates that all other models satisfy TRIDENT's protection requirements for MEC 95.

Relative to the benchmark, each FLSIP model (FLSIP, Mod FLSIP I and Mod FLSIP II) increased range by about 1,000 items. The large increase in range for each FLSIP model was attributed to using a lower exclusion criterion (each FLSIP model uses an exclusion of .25 whereas the benchmark uses an exclusion of .4216). Each FLSIP model also produced significant increases in cost ($82K-$102K) and range effectiveness (7%-14%). However, increases in units effectiveness were not as large. These increases ranged from 1% for both FLSIP and Mod FLSIP I to 3% for Mod FLSIP II. The Variable Protection I model, which does not stock all items in this MEC category, produced only a slight increase in range, cost, and effectiveness.

TABLE XIII

COMPARISONS OF ALTERNATIVE MODELS
MEC 95 ITEMS

SHIP	MODEL	RANGE	$ VALUE	RANGE EFF (OVERALL)	RANGE EFF (AVG QTR)	UNITS EFF (AVG QTR)
SSBN 627	TRIDENT Goal*	3,127	307K	63%	80%	55%
	FLISP	4,088	389K	74%	87%	55%
	Mod FLSIP I	4,088	389K	74%	87%	55%
	Mod FLSIP II	4,088	396K	74%	87%	56%
	Variable Prot I	3,295	325K	65%	81%	55%
	Variable Prot II	5,576	270K	78%	88%	64%
SSBN 633	TRIDENT Goal*	3,161	327K	57%	75%	54%
	FLSIP	4,138	419K	71%	86%	55%
	Mod FLSIP I	4,138	419K	71%	86%	55%
	Mod FLSIP II	4,138	429K	71%	86%	57%
	Variable Prot I	3,339	352K	60%	77%	55%
	Variable Prot II	5,821	310K	77%	88%	65%

*This model is considered the benchmark for all comparisons

As in previous MEC categories, the most cost-effective results were provided by the Variable Protection II model. This model not only produced the highest range, range effectiveness, and units effectiveness, but also was lower in cost than any other model. It should be noted that units effectiveness and range were substantially higher than any other model. However, the higher range resulted in only a

slight increase in range effectiveness when compared with each FLSIP model.

8. Total Ship. Comparisons for the total ship (all MEC categories combined) are summarized in Table XIV. As mentioned earlier, total ship statistics are overstated due to the large number of items assigned MEC 116. However, the results for each model are valid for comparison purposes. In comparing each model, it should be kept in mind that TRIDENT has no specified protection goal for the total ship.

Compared to the benchmark, the FLSIP model produced very large decreases in both range and dollar value. This was mainly attributed to the fact that FLSIP was the only model which did not stock all items in MEC 116. The results for average quarterly range effectiveness were different for each ship. It was 2% lower for SSBN 627, but was 3% higher for SSBN 633. FLSIP also decreased units effectiveness by 2%-3%.

The Mod FLSIP I was an improvement over the FLSIP model. It produced a similar range as compared to the TRIDENT Goal model, but was slightly lower in cost and units effectiveness. Although range was similar for both the benchmark and Mod FLSIP I, it was earlier seen that the mix of items in each model was different in MECs 95 to 110. Mod FLSIP I had a larger range in MEC 95, while the benchmark had a

TABLE XIV

COMPARISON OF ALTERNATIVE MODELS
TOTAL SHIP

SHIP	MODEL	RANGE	$ VALUE	RANGE EFF (OVERALL)	RANGE EFF (AVG QTR)	UNITS EFF (AVG QTR)
SSBN 627	TRIDENT Goal*	17,034	1.22M	78%	88%	58%
	FLSIP	7,345	.61M	72%	86%	55%
	Mod FLSIP I	17,054	1.12M	82%	91%	56%
	Mod FLSIP II	17,054	1.25M	82%	91%	58%
	Variable Prot I	19,804	1.36M	81%	90%	62%
	Variable Prot II	19,055	1.04M	85%	92%	66%
SSBN 633	TRIDENT Goal*	13,249	1.13M	71%	84%	63%
	FLSIP	7,266	.71M	71%	87%	61%
	Mod FLSIP I	12,997	.99M	76%	89%	62%
	Mod FLSIP II	12,997	1.16M	76%	89%	64%
	Variable Prot I	16,509	1.32M	75%	86%	67%
	Variable Prot II	15,467	.94M	81%	91%	72%

*This model is considered the benchmark for all comparisons

larger range in MECs 98 to 110. It is also noted that Mod FLSIP I produced a 3%-5% increase in range effectiveness. This was mainly attributed to two factors: (1) over half of the model candidates demanded were coded MEC 95; and (2) Mod FLSIP I produced a much larger range in MEC 95.

The Mod FLSIP II model, which stocked the same items as Mod FLSIP I but provided greater depth, produced a slight

increase in cost and units effectiveness. Similar to Mod FLSIP I, this model also produced a 3%-5% increase in range effectiveness.

The Variable Protection I model which stocked all items in MEC 98 to 116, produced the highest range and cost. It also produced a 2% increase in the average quarterly range effectiveness and a 4% increase in units effectiveness.

Of the six test models evaluated, the most cost-effective results were provided by the Variable Protection II model. This model not only produced the best effectiveness, but also was lower in cost than all models except FLSIP. Range was also higher than all models except the Variable Protection I model. Compared to the benchmark, the Variable Protection II model increased range by about 2,000 items, while reducing cost by about $200K. It also produced a 4%-7% increase in the average quarterly range effectiveness, an 8%-10% increase in overall effectiveness and an 8%-9% increase in units effectiveness.

9. Impact of MEC 116 Override. Since the number of items in MEC 116 was considered to be unrealistically high, this caused range, cost, and effectiveness statistics for the total ship to be overstated for each model. This section evaluates the impact on the total ship statistics of eliminating the MEC 116 override for both the TRIDENT Goal model and the Variable Protection II model. It is recalled that both these models stock all items in MEC 116. Each of these models was compared with a similar model which excluded

the MEC 116 override feature. The TRIDENT Goal model without the MEC 116 override feature treats each MEC 116 item as a MEC 110 item (i.e., each MEC 116 item was protected to 99%). The Variable Protection II model without the MEC 116 override feature does not force each MEC 116 item to be included on the COSAL.

Table XV shows that if fewer items were assigned a MEC 116, range and dollar value would be substantially reduced with little impact on effectiveness. The expected range for

TABLE XV

IMPACT OF MEC 116 OVERRIDE
TOTAL SHIP

SHIP	MODEL	RANGE	$ VALUE	RANGE EFF (OVERALL)	RANGE EFF (AVG QTR)	UNITS EFF (AVG QTR)
SSBN 627	TRIDENT Goal	17,034	1.22M	78%	88%	58%
	TRIDENT Goal*	10,295	.81M	75%	87%	57%
	Variable Prot II	19,055	1.04M	85%	92%	66%
	Variable Prot II*	13,487	.64M	83%	91%	66%
SSBN 633	TRIDENT Goal	13,249	1.13M	71%	84%	63%
	TRIDENT Goal*	9,420	.80M	70%	83%	62%
	Variable Prot II	15,467	.94M	81%	91%	72%
	Variable Prot II*	12,337	.67M	81%	90%	72%

*No MEC 116 Override

a given model would then be between the range of the model which includes the MEC 116 override feature and the range of the model without the MEC 116 override feature. For example, the expected range for the Variable Protection II model would be between 13,487 and 19,055 for SSBN 627.

C. CONVENTIONAL MODEL COMPARISON. This section compares the Conventional model with the best test model. It was seen from the previous section that the most cost-effective test model was the Variable Protection II model. For comparison of these two models, four statistics were computed: range, dollar value, overall range effectiveness, and the average quarterly units effectiveness. The average quarterly range effectiveness was not computed. In computing effectiveness, total demands (demands for both candidate items and non-candidate items) were used to establish a common basis for comparison since the COSAL candidates selected for the test models were different from those slected for the Conventional model. The COSAL candidates selected for the test models were based on the maintenance code, while those selected for the Conventional model were based on the allowance factor code.

In comparing these two models, it should be kept in mind that Conventional quantities basically reflect provisioning decisions. These quantities are updated over time to adequately

support problem items and also to eliminate the slow moving items. Comparison of the Conventional model with the TRIDENT Goal model and the Variable Protection II model is shown in Table XVI for SSBN 633. No results are shown for SSBN 627 due to an incomplete COSAL candidate file for Conventional candidates.

The results indicate that the Conventional model will perform better than the TRIDENT Goal model as it produced 3% higher units effectiveness and 8% higher range effectiveness than the benchmark. Relative to the benchmark, the Conventional model also reduced range, while increasing cost.

Comparing the Variable Protection II model with the Conventional model shows that both these models produced the same range effectiveness. However, the Variable Protection II model had 3% higher units effectiveness. It is also noted that cost was significantly lower for the Variable Protection II model, despite a higher range. Again, the statistics clearly show that the most cost-effective results were provided by the Variable Protection II model.

TABLE XVI

COMPARISON OF CONVENTIONAL MODEL
SSBN 633

MODEL	RANGE	$ VALUE	RANGE EFF* (OVERALL)	UNITS EFF* (AVG QTR)
TRIDENT Goal (benchmark)	13,249	1.13M	52%	41%
Variable Prot II	15,467	.94M	60%	47%
Variable Prot II No MEC 116 Override	12,337	.67M	60%	47%
Conventional	11,952	1.31M	60%	44%

*Effectiveness was computed using total demands

D. CONSTRAINED MODEL COMPARISON. The results of this study were presented to representatives of OPNAV, NAVMAT, NAVSEA, NAVSUP, and SPCC during reference (4). The protection levels in the Variable Protection II model, as shown in Table IV of Appendix B, were deemed unsatisfactory for expensive low MEC items, and a constraint to provide a minimum 90% protection level for all items was directed. The impact of this constraint is shown in Tables XVII and XVIII. As expected, the major impact was on MEC 95 items. The range for MEC 95 increased less than 100 items, but the investment increased $67K-77K. Range effectiveness increased 1-2%, while units effectiveness increased 0-1%. The impact on the total ship was to increase range less than 100 items, increase dollar value by 8% (about $70K-80K), and increase range effectiveness 1%. There was no change in total units effectiveness.

TABLE XVII

IMPACT OF CONSTRAINED MODEL
SSBN 627

MEC	MODEL	RANGE	$ VALUE	RANGE EFF (OVERALL)	RANGE EFF (AVG QTR)	UNITS EFF (AVG QTR)
95	Constrained*	5,641	347K	80%	90%	65%
	Variable Prot II	5,576	270K	78%	88%	64%
98	Constrained*	1,533	103K	87%	95%	69%
	Variable Prot II	1,530	101K	87%	95%	69%
101	Constrained*	173	13K	97%	99%	67%
	Variable Prot II	172	11K	97%	99%	67%
107	Constrained*	754	39K	83%	92%	76%
	Variable Prot II	753	39K	83%	92%	76%
110	Constrained*	50	3K	100%	100%	94%
	Variable Prot II	50	3K	100%	100%	94%
116	Constrained*	10,974	612K	100%	100%	76%
	Variable Prot II	10,974	612K	100%	100%	76%
All	Constrained*	19,125	1.12M	86%	93%	66%
MECs	Variable Prot II	19,055	1.04M	85%	92%	66%

*Constrained model is a Variable Protection II model with a minimum protection of 90% for all items

TABLE XVIII

IMPACT OF CONSTRAINED MODEL
SSBN 633

MEC	MODEL	RANGE	$ VALUE	RANGE EFF (OVERALL)	RANGE EFF (AVG QTR)	UNITS EFF (AVG QTR)
95	Constrained*	5,907	377K	79%	89%	65%
	Variable Prot II	5,821	310K	77%	88%	65%
98	Constrained*	1,538	99K	87%	95%	77%
	Variable Prot II	1,535	96K	87%	95%	77%
101	Constrained*	310	11K	70%	76%	63%
	Variable Prot II	310	11K	70%	76%	63%
107	Constrained*	1,223	60K	79%	91%	87%
	Variable Prot II	1,223	60K	79%	91%	87%
110	Constrained*	49	3K	100%	100%	98%
	Variable Prot II	49	3K	100%	100%	98%
116	Constrained*	6,529	461K	100%	100%	88%
	Variable Prot II	6,529	461K	100%	100%	88%
ALL	Constrained*	15,556	1.01M	82%	92%	72%
MECs	Variable Prot II	15,467	.94M	81%	91%	72%

*Constrained model is a Variable Protection II model with a minimum protection of 90% for all items

IV. SUMMARY

This study has evaluated seven alternative COSAL models for the TRIDENT submarine. The TRIDENT Goal model, which directly addresses the TRIDENT protection goals was considered as the benchmark. The findings of each model relative to the benchmark are summarized below:

- <u>FLSIP</u>. The FLSIP model produced the largest decreases in range, cost, and effectiveness. This model did not meet TRIDENT protection requirements since it produced lower units effectiveness in MECs 98 to 116. The only MEC category in which FLSIP met TRIDENT protection requirements was MEC 95.
- <u>Mod FLSIP I</u>. The Mod FLSIP I model was an improvement over the FLSIP model. However, this model still did not meet TRIDENT protection requirements since it produced lower units effectiveness in MECs 98 to 116. Similar to FLSIP, the only MEC category in which Mod FLSIP I met TRIDENT protection requirements was MEC 95.
- <u>Mod FLSIP II</u>. The Mod FLSIP II model stocks the same items as Mod FLSIP I but provides greater depth. For the total ship this model produced a similar range to the benchmark, but was slightly

higher in dollar value and units effectiveness. Within MEC category, Mod FLSIP II generally produced lower range, cost, and effectiveness in MECs 98 to 107. Thus, Mod II did not meet TRIDENT protection requirements.

- Variable Protection I. The Variable Protection I model varies item protection based on MEC and unit price. This model stocks all items in MECs 98 to 116. For the total ship, this model produced the highest range and cost. It also was 2% higher than the benchmark in average quarterly range effectiveness and 4% higher in units effectiveness. This model met TRIDENT protection requirements since it produced higher units effectiveness in each MEC category.

- Variable Protection II. The Variable Protection II model is a modification of the Variable Protection I model. For the total ship, this model produced the highest units effectiveness. It was also lower in cost than all models except FLSIP. Similar to the Variable Protection I model, this model also met TRIDENT protection requirements since it produced higher units effectiveness in each MEC category. The only deficiency in the Variable Protection II model was in range effectiveness. Although range

effectiveness was higher for the total ship, it was slightly lower in MECs 98 to 107.

- Conventional. The Conventional model is currently used to compute allowances for SSBNs. This model outperforms the benchmark for the total ship as it produces 3% higher units effectiveness. However, since this model does not directly consider MEC in determining allowances, it is questionable whether this model will satisfy TRIDENT protection requirements within MEC category.
- Constrained Variable Protection II. This model is identical to the Variable Protection II model except that all items are given a minimum protection level of 90%. This model met the TRIDENT protection requirements since it produced higher units effectiveness in each MEC category. Similar to the Variable Protection II model, the only deficiency was in range effectiveness for MECs 98 to 107.

Of the alternative models evaluated, four models met TRIDENT protection requirements in each MEC category--the TRIDENT Goal model, the Variable Protection I model, the Variable Protection II model, and the Constrained Variable Protection II model. The results for these four models are summarized for each MEC category in Tables XIX and XX.

TABLE XIX

SSBN 627 SUMMARY

MEC	MODEL	RANGE	$ VALUE	RANGE EFF (OVERALL)	RANGE EFF (AVG QTR)	UNITS EFF (AVG QTR)
95	TRIDENT Goal	3,127	307K	63%	80%	55%
	Variable Prot I	3,295	325K	65%	81%	55%
	Variable Prot II	5,576	270K	78%	88%	64%
	Constrained Var Prot II	5,641	347K	80%	90%	65%
98	TRIDENT Goal	1,953	192K	97%	99%	64%
	Variable Prot I	2,757	294K	100%	100%	72%
	Variable Prot II	1,530	101K	87%	95%	69%
	Constrained Var Prot II	1,533	103K	87%	95%	69%
101	TRIDENT Goal	206	21K	97%	99%	61%
	Variable Prot I	289	32K	100%	100%	71%
	Variable Prot II	172	11K	97%	99%	67%
	Constrained Var Prot II	173	13K	97%	99%	67%
107	TRIDENT Goal	724	51K	83%	94%	70%
	Variable Prot I	2,424	96K	100%	100%	81%
	Variable Prot II	753	39K	83%	92%	76%
	Constrained Var Prot II	754	39K	83%	92%	76%
110	TRIDENT Goal	50	3K	100%	100%	85%
	Variable Prot I	65	4K	100%	100%	95%
	Variable Prot II	50	3K	100%	100%	94%
	Constrained Var Prot II	50	3K	100%	100%	94%
116	TRIDENT Goal	10,974	645K	100%	100%	68%
	Variable Prot I	10,974	612K	100%	100%	76%
	Variable Prot II	10,974	612K	100%	100%	76%
	Constrained Var Prot II	10,974	612K	100%	100%	76%
ALL MECs	TRIDENT Goal	17,034	1.22M	78%	88%	58%
	Variable Prot I	19,804	1.36M	81%	90%	62%
	Variable Prot II	19,055	1.04M	85%	92%	66%
	Constrained Var Prot II	19,125	1.12M	86%	93%	66%

TABLE XX

SSBN 633 SUMMARY

MEC	MODEL	RANGE	$ VALUE	RANGE EFF (OVERALL)	RANGE EFF (AVG QTR)	UNITS EFF (AVG QTR)
95	TRIDENT Goal	3,161	327K	57%	75%	54%
	Variable Prot I	3,339	352K	60%	77%	55%
	Variable Prot II	5,821	310K	77%	88%	65%
	Constrained Var Prot II	5,907	377K	79%	89%	65%
98	TRIDENT Goal	1,967	181K	95%	98%	71%
	Variable Prot I	2,788	289K	100%	100%	80%
	Variable Prot II	1,535	96K	87%	95%	77%
	Constrained Var Prot II	1,538	99K	87%	95%	77%
101	TRIDENT Goal	358	20K	79%	88%	64%
	Variable Prot I	864	40K	100%	100%	75%
	Variable Prot II	310	11K	70%	76%	63%
	Constrained Var Prot II	310	11K	70%	76%	63%
107	TRIDENT Goal	1,185	80K	82%	93%	81%
	Variable Prot I	2,923	170K	100%	100%	91%
	Variable Prot II	1,223	60K	79%	91%	87%
	Constrained Var Prot II	1,223	60K	79%	91%	87%
110	TRIDENT Goal	49	3K	100%	100%	90%
	Variable Prot I	66	5K	100%	100%	98%
	Variable Prot II	49	3K	100%	100%	98%
	Constrained Var Prot II	49	3K	100%	100%	98%
116	TRIDENT Goal	6,529	524K	100%	100%	81%
	Variable Prot I	6,529	461K	100%	100%	88%
	Variable Prot II	6,529	461K	100%	100%	88%
	Constrained Var Prot II	6,529	461K	100%	100%	88%
ALL MECs	TRIDENT Goal	13,249	1.13M	71%	84%	63%
	Variable Prot I	16,509	1.32M	75%	86%	67%
	Variable Prot II	15,467	.94M	81%	91%	72%
	Constrained Var Prot II	15,556	1.01M	82%	92%	72%

These tables show that the Variable Protection II model will provide the best units effectiveness for the dollars invested. This model was recommended for approval by reference (4). The model was approved with the stipulation that a constraint be added to ensure a minimum item protection level of 90% for all items. The stipulation has been incorporated into the recommended model and is now ready for SPCC.

The approved model does not directly address the TRIDENT protection goals; however, based on existing SSBN data, it has been demonstrated that the model does meet the TRIDENT requirements. This study assumes that TRIDENT submarine configuration data, on-board maintenance philosophy and experienced usage will be similar to existing SSBN data. It is highly recommended that implementation and early operation of the TRIDENT COSAL model be closely monitored to prove the validity of the assumption and ensure that the desired levels of protection are attained.

APPENDIX A: REFERENCES

1. NAVSEA ltr PMS 396/CRP of 29 Apr 1976.
2. SSPINST 4423.27B of 9 Jul 1974.
3. SPCC memo 880-1/vms 4441 of 14 Apr 1976.
4. FMSO presentation to OPNAV (OP-41) of 16 Dec 1976.

APPENDIX B: COSAL MODELS

This appendix describes the seven alternative COSAL models which were evaluated for the TRIDENT submarine. The seven models include the current Conventional model, the FLSIP model, a model which directly addresses TRIDENT protection goals, two modified FLSIP models and two variable protection models. All models are designed to provide 90 days support.

In all models except the Conventional model, all Technical Overrides and Planned Maintenance Requirements currently designated for the two test ships are considered as minimum quantity overrides. The volume of current Planned Maintenance Requirements was extremely small and is not considered representative of the TRIDENT maintenance philosophy.

1. <u>CONVENTIONAL MODEL</u>. The Conventional model is currently used to compute allowances for all SSBNs. This model is really a set of two criteria for different segments of the COSAL. The support for ordnance equipments is determined based on the FLSIP criteria used for non-FBM ships, with consideration given to usage data. The support for hull, mechanical, electrical, and electronic equipments is determined by manual procedures, in which fixed allowance quantities are assigned at the time of provisioning. These procedures do not directly consider usage data, MEC or

protection level in determining the allowance quantities. These quantities are manually revised only on an exception basis.

2. FLSIP MODEL. The FLSIP model is currently used to compute allowances for all non-FBM ships. This model considers only ship installable items as allowance candidates. A 90 day demand forecast (μ) is computed for each candidate as follows:

$$\mu = \frac{BRF \times POP}{4}$$

Here, the BRF represents the Best Replacement Factor, an estimate of the annual usage rate for the part based on fleet-wide usage, and POP is the total part installed population across all component applications. Each candidate is then segmented into one of two categories--demand based or insurance--based on its expected demand forecast. If the expected demand forecast is one or more units per quarter, the candidate is classified as a demand based item. Each demand based item is stocked in sufficient depth to provide 90% protection against stockout. If the expected demand forecast is less than one unit per quarter, the candidate is classified as an insurance item. Each insurance item is stocked only if its expected demand forecast is greater than or equal to a value known as the deep insurance criterion or exclusion criterion. This value is currently set at .0625 units per quarter (or .25 units per year). The FLSIP model also requires that an insurance

item have a vital part to component MEC and that the component to mission MEC be vital. However, these MEC criteria were excluded for this study. Each insurance item which passes the exclusion criterion (i.e., its expected demand forecast is greater than or equal to the exclusion criterion) is stocked in a quantity of one MRU (Minimum Replacement Unit). Insurance items not passing the exclusion criteria are not allowed unless there is a Planned Maintenance Requirement or Technical Override.

3. TRIDENT GOAL MODEL. The TRIDENT Goal model was developed by modifying the FLSIP model to meet TRIDENT protection goals. The protection level for each demand based item was set to the TRIDENT requirement for each MEC category. Specifically, items with MEC 116 were protected to 99.99%, while items with a MEC of 98 to 110 were protected to 99%, and items with MEC 95 were protected to 90%. The exclusion criterion for each insurance item was varied by MEC category. In each MEC category except MEC 116, it was set to that value of μ (expected usage in 90 days) which would necessitate stocking at least a minimum depth of one to satisfy TRIDENT's required protection. Specifically, insurance items with MEC 95 were excluded if the expected annual demand was less than .4216 units per year, since a quantity of zero would satisfy a 90% protection level for these items. Items with a MEC of

98 to 110 were excluded if the expected annual demand was less than .0404 units per year. Insurance items with MEC 116 were given an exclusion criterion of 0 to ensure that these items would always be stocked since lack of MEC 116 items during a failure could cause the submarine to abort its mission. Each insurance item which passed the exclusion criteria was stocked in sufficient depth to meet TRIDENT's specified protection level. Insurance items not passing the exclusion criteria were not allowed unless there was a Planned Maintenance Requirement or Technical Override.

4. MOD FLSIP I MODEL. The Mod FLSIP I model was also developed by modifying the FLSIP model. Similar to the TRIDENT Goal model, the protection level for each demand based item was set to TRIDENT's requirement for each MEC category. The exclusion criterion for each insurance item was also varied by MEC category. Exclusion values, arbitrarily assigned for each MEC category, were 0 for MEC 116 items, .05 for MEC 110 items, .10 for MEC 107 items, .15 for MEC 98-104 items, and .25 for MEC 95 items. Insurance items which passed the exclusion criteria were stocked in a quantity of one MRU, while those not passing were excluded unless there was a Planned Maintenance Requirement or Technical Override.

5. <u>MOD FLSIP II MODEL</u>. The Mod FLSIP II model is the same as the Mod FLSIP I model except each insurance item which passed the exclusion criterion was stocked in sufficient depth to meet TRIDENT's specified protection level rather than constraining the item depth to one MRU. Compared with the Mod FLSIP I model, this model will stock the same range, but will provide greater depth.

6. <u>VARIABLE PROTECTION I MODEL</u>. The Variable Protection I model tested in this study is similar to that currently specified in SSPINST 4423.27B for support of the FBM Weapon System. The Variable Protection I allowance quantities (AQ) are computed as follows:

$$AQ = \mu + 1.3\sqrt{\mu} \text{ for MEC 95}$$

$$AQ = \mu + [7 - \frac{1}{6}(116\text{-MEC}) - \log_{10} P]\sqrt{\mu} + .5 \text{ for MECs 98 to 116}$$

where

μ = 90 day expected demand

P = unit price

The following paragraphs explain the rationale behind the above formulae.

The Variable Protection I model assumes that demand is Poisson distributed. Then, to simplify the mathematical

computations, the model uses a Normal approximation to compute the Poisson quantities. Using the Normal approximation, the allowance quantity can be expressed very simply as

$$AQ = \mu + t\,\sigma$$

where

μ = mean = 90 day expected demand

t = Normal standard unit--measurement of number of standard deviations from mean

σ = standard deviation of demand

Since it was assumed that demand is Poisson distributed, the standard deviation is equal to the square root of the mean and the above formula becomes

$$AQ = \mu + t\sqrt{\mu}$$

It is noted that this is the basic form of the Variable Protection I formulae where $t = 1.3$ for MEC 95 items and $t = [7 - \frac{1}{6}(116\text{-MEC}) - \log_{10} P]$ for MEC 98 to 116 items.

The value of t determines the number of standard deviations to be added to the mean to obtain the allowance quantity and thus directly correlates to a protection level as shown in Table I.

TABLE I

CORRELATION OF t VALUE TO PROTECTION LEVEL

VALUE OF t	PROTECTION LEVEL
1.3	90%
2.3	99%
3.3	99.9%
4.3	99.99%
5.3	99.999%
6.3	99.9999%

In the Variable Protection I model, the protection level for each MEC 95 item is fixed at 90% ($t = 1.3$). For the remaining items, protection is varied by MEC and unit price. The expression for t for MEC 98 to 116 items is structured to provide specified protection levels for the "average" item, varying from 90% to 99.99% as shown in Table II. The "average" item is defined to have a unit price of $500.

The expression for t further provides that for a given MEC, items with a unit price lower than the average price will receive a higher protection while items with a higher unit price will receive a lower protection. The log function was arbitrarily selected as the scaling factor for measuring the degree of difference in unit prices. The impact of price variations for a MEC 104 item is shown in Table III.

TABLE II

PROTECTION LEVEL FOR AVERAGE ITEM

MEC	VALUE OF $[7 - \frac{1}{6}(116\text{-MEC}) - \log_{10} 500]^*$	PROTECTION
116	4.3	99.99%
110	3.3	99.9%
107	2.8	99.7%
104	2.3	99%
101	1.8	96%
98	1.3	90%

$^*\log_{10} 500 = 2.7$

TABLE III

PROTECTION LEVELS FOR MEC 104 ITEMS

UNIT PRICE	VALUE OF $[7 - \frac{1}{6}(116\text{-}104) - \log_{10} \text{PRICE}]$	PROTECTION
$5	4.3	99.99%
$50	3.3	99.9%
$500	2.3	99%
$5000	1.3	90%

The $500 value for the average item was arbitrarily selected and may be high in light of the current FBM price distribution shown in Table IV of the main report. However, it has also

been suggested that the average price for TRIDENT submarine parts may be higher than existing submarines because of the modular repair philosophy.

In applying the Variable Protection I model, the computed allowance quantity is rounded to the nearest whole number. If this value is greater than or equal to one, the item is allowed on the COSAL; otherwise, it is not stocked unless there is a Planned Maintenance Requirement or Technical Override. Note that a quantity of .5 is added for each item with a MEC of 98 to 116. This quantity together with the rounding rule acts as an override which forces these items to be always included on the COSAL.

7. <u>VARIABLE PROTECTION II MODEL</u>. The Variable Protection II model was developed by modifying the Variable Protection I model. This model provides a variable protection level for all items based on MEC and unit price. Formulae to compute allowance quantities were changed to the following:

$$AQ = \mu + [7 - \frac{1}{6}(116\text{-MEC}) - \log_{10} P]\sqrt{\mu} \text{ for MECs}$$

95 to 110

$$AQ = \mu + [7 - \frac{1}{6}(116\text{-MEC}) - \log_{10} P]\sqrt{\mu} + .5 \text{ for MEC}$$

116 items

The above formulae show that this model is the same as the Variable Protection I model except items with MEC 95 are provided variable protection based on MEC and unit price instead of a fixed 90% protection, and items with a MEC of 98 to 110 are not forced to be included on the COSAL.

The protection level provided for various MEC and unit price combinations is shown in Table IV. As described in the Variable Protection I model, the protection level increases as the essentiality of the item increases, and cheaper items are given higher protection than more expensive items. The protection level for a MEC 116 item varies from 99.9% for $5000 items to 99.9999% for a $1 item. It should be noted that the protection level drops below 90% for some high cost items.

TABLE IV

PROTECTION LEVEL FOR VARIABLE PROTECTION II MODEL

UNIT PRICE	MEC						
	95	98	101	104	107	110	116
$1	99.9^+	99.9^+	99.99^+	99.99^+	99.999^+	99.999^+	99.9999^+
$5	99^+	99.9	99.9^+	99.99	99.99^+	99.999	99.9999
$10	99^+	99^+	99.9^+	99.9^+	99.99^+	99.99^+	99.999^+
$50	96	99	99^+	99.9	99.9^+	99.99	99.999
$100	93	98	99^+	99^+	99.9^+	99.9^+	99.99^+
$500	79	90	96	99	99^+	99.9	99.99
$1000	69	84	93	98	99^+	99^+	99.9^+
$5000	50	62	79	90	96	99	99.9

NOTE: $^+$indicates that the protection level exceeds that value shown but is less than that value with one more nine on the end. For example, 99.9^+ means that the protection exceeds 99.9% but is less than 99.99%.

These protection levels were determined based on Table I with

$$t = [7 - \frac{1}{6} (116\text{-MEC}) - \log_{10} \text{price}]$$

APPENDIX C: MODEL CANDIDATE DISTRIBUTIONS

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TABLE I

MEC VS UNIT PRICE*
SSBN 627

UNIT PRICE	MEC						TOTAL
	95	98	101	107	110	116	
≤ 1.00	4,114	558	81	1,033	13	5,004	10,803
1.01 - 5.00	3,367	660	79	565	5	2,660	7,336
5.01 - 10.00	1,325	245	26	218	4	841	2,659
10.01 - 50.00	3,122	783	54	408	31	1,431	5,829
50.01 - 100.00	723	162	16	80	3	368	1,352
100.01 - 500.00	1,139	285	23	82	9	493	2,031
500.01 - 1000.00	237	30	4	22	0	83	376
> 1000.00	181	34	6	16	0	94	331
TOTAL	14,208	2,757	289	2,424	65	10,974	30,717

*These statistics are based on random MEC assignment

TABLE II

MEC VS UNIT PRICE*
SSBN 633

UNIT PRICE	MEC						TOTAL
	95	98	101	107	110	116	
≤ 1.00	5,358	547	347	1,136	11	3,035	10,434
1.01 - 5.00	3,921	680	269	681	8	1,655	7,214
5.01 - 10.00	1,635	260	66	223	6	446	2,636
10.01 - 50.00	3,560	795	92	498	30	792	5,767
50.01 - 100.00	849	163	27	146	2	172	1,359
100.01 - 500.00	1,355	282	51	182	9	302	2,181
500.01 - 1000.00	282	27	5	28	0	81	423
> 1000.00	218	34	7	29	0	46	334
TOTAL	17,178	2,788	864	2,923	66	6,529	30,348

*These statistics are based on random MEC assignment

TABLE III

MEC VS EXPECTED ANNUAL DEMAND*
SSBN 627

ANNUAL DEMAND (μ)	MEC 95	98	101	107	110	116	TOTAL
$0 \leq \mu \leq .0404$	6,287	845	86	1,723	15	6,897	15,853
$.0404 < \mu \leq .0500$	463	114	18	59	4	400	1,058
$.0500 < \mu \leq .1000$	1,681	465	43	190	9	1,143	3,531
$.1000 < \mu \leq .1500$	917	224	19	85	4	480	1,729
$.1500 < \mu \leq .2500$	1,148	261	20	93	7	496	2,025
$.2500 < \mu \leq .4216$	993	205	15	67	7	388	1,675
$.4216 < \mu \leq 1.0000$	1,221	231	33	75	8	470	2,038
$1.0000 < \mu \leq 4.0000$	1,017	248	30	86	7	395	1,783
$\mu > 4.0000$	481	164	25	46	4	305	1,025
TOTAL	14,208	2,757	289	2,424	65	10,974	30,717

*These statistics are based on random MEC assignment

TABLE IV

MEC VS EXPECTED ANNUAL DEMAND*
SSBN 633

	MEC						
ANNUAL DEMAND (μ)	95	98	101	107	110	116	TOTAL
$0 \leq \mu \leq .0404$	8,793	862	530	1,758	17	3,945	15,905
$.0404 < \mu \leq .0500$	552	121	40	115	3	213	1,044
$.0500 < \mu \leq .1000$	2,005	480	98	307	6	678	3,574
$.1000 < \mu \leq .1500$	1,040	225	35	142	5	290	1,737
$.1500 < \mu \leq .2500$	1,146	256	35	148	5	308	1,898
$.2500 < \mu \leq .4216$	1,017	221	31	139	9	271	1,688
$.4216 < \mu \leq 1.0000$	1,163	228	40	135	10	324	1,900
$1.0000 < \mu \leq 4.000$	972	220	30	106	8	309	1,645
$\mu > 4.0000$	490	175	25	73	3	191	957
TOTAL	17,178	2,788	864	2,923	66	6,529	30,348

*These statistics are based on random MEC assignment

TABLE V

UNIT PRICE VS EXPECTED ANNUAL DEMAND
SSBN 627

ANNUAL DEMAND (μ)	UNIT PRICE								TOTAL
	≤ 1.00	1.01-5.00	5.01-10.00	10.01-50.00	50.01-100.00	100.01-500.00	500.01 1000.00	> 1000.00	
$0 \leq \mu \leq .0404$	5,680	3,563	1,301	3,513	632	845	163	150	15,853
$.0404 < \mu \leq .0500$	321	291	90	184	49	89	15	19	1,058
$.0500 < \mu \leq .1000$	986	927	342	618	198	345	58	57	3,531
$.1000 < \mu \leq .1500$	495	438	162	290	104	182	35	23	1,729
$.1500 < \mu \leq .2500$	637	530	200	323	110	169	28	28	2,025
$.2500 < \mu \leq .4216$	502	443	170	284	89	139	25	23	1,675
$.4216 < \mu \leq 1.0000$	735	533	189	294	87	149	32	19	2,038
$1.0000 < \mu \leq 4.0000$	815	373	135	257	73	103	15	12	1,783
$\mu > 4.0000$	626	238	70	66	10	10	5	0	1,022
TOTAL	10,803	7,336	2,659	5,829	1,352	2,031	376	331	30,717

TABLE VI

UNIT PRICE VS EXPECTED ANNUAL DEMAND
SSBN 633

ANNUAL DEMAND (μ)	UNIT PRICE								TOTAL
	≤ 1.00	1.01-5.00	5.01-10.00	10.01-50.00	50.01-100.00	100.01-500.00	500.01 1000.00	> 1000.00	
0 ≤ μ ≤ .0404	5,584	3,639	1,309	3,497	655	915	156	150	15,905
.0404 < μ ≤ .0500	311	268	89	186	49	100	22	19	1,044
.0500 < μ ≤ .1000	968	914	326	630	199	398	87	52	3,574
.1000 < μ ≤ .1500	469	412	179	298	112	193	53	21	1,737
.1500 < μ ≤ .2500	550	487	202	321	100	179	28	31	1,898
.2500 < μ ≤ .4216	542	431	168	259	82	153	26	27	1,688
.4216 < μ ≤ 1.0000	689	492	161	282	82	138	35	21	1,900
1.0000 < μ ≤ 4.0000	735	351	138	233	67	96	12	13	1,645
μ > 4.0000	586	220	64	61	13	9	4	0	957
TOTAL	10,434	7,214	2,636	5,767	1,359	2,181	423	334	30,348

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13. ABSTRACT

This study evaluates alternative COSAL (Coordinated Shipboard Allowance List) models for the TRIDENT submarine using POLARIS/POSEIDON submarine data. Performance is measured by the range of items, overall cost and resulting effectiveness, where effectiveness is based on actual submarine usage. The objective is to develop a COSAL to meet TRIDENT performance goals. These protection goals vary by MEC (Military Essentiality Code) from 90% to 99.99%. The recommended model provides variable item protection based on MEC and unit price. It attains TRIDENT objectives and was the most cost-effective model examined.

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